

destroyed by crows does not strengthen this contention. Of the 156 nests so destroyed (item 2), 66 contained completed sets of eggs and 17 were definitely incomplete, but for the remaining 73, no certain deduction could be made regarding their completeness.

Included in the 53 recorded instances of destruction by unknown cause (item 3) were the suspected work of the crow, previously mentioned, and also many cases in which the evidence pointed toward but did not definitely incriminate muskrats, skunks, or domestic livestock.

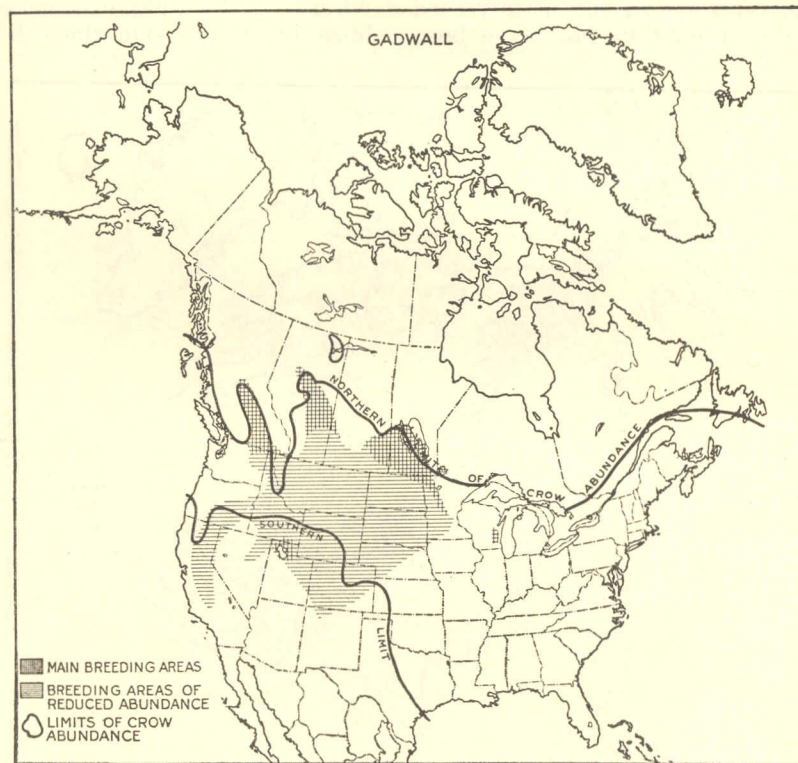


FIGURE 10.—Relation of areas of crow abundance to the breeding range of the gadwall.

Though only a relatively small proportion of the nests were deserted by the female (item 4), desertion becomes a matter of more than ordinary interest, since it may reflect some weakness of the observational method of approach to this problem (pp. 4 to 7). In several of the nests that ultimately were deserted, one or more reductions in the number of eggs by outside agencies may have contributed to the inconstancy of the incubating bird. In 10 deserted nests the sets of eggs appeared to have been completed and incubation started, in 13 they were definitely incomplete, and in 15 their status could not be determined. The two remaining deserted nests were "community" affairs into which several females had dropped eggs.

Under item 5 are included several types of disaster in which the females were killed during the egg-laying and incubating periods. In two instances evidence pointed to the work of predatory birds; in five others minks and weasels were to blame; in another an unknown predator was involved; and in the remaining case the female experienced a most unusual fate, for in approaching or leaving her nest one leg became so entangled in a coarse stem of *Carex* that she could not release herself.

Single nests failed to produce young because of an egg collector, trampling by sheep, fire, and infertility (items 6 to 9).

#### FATE OF NESTS OF WATERFOWL OF VARIOUS SPECIES

Segregation of the fate of nests by species brings to light some facts difficult of explanation (table 2). Of the 7 species for each of which there are at least 20 completed nest histories available, it is noted that the canvasback was the most successful in bringing off young, with the shoveler a close second. The mallard, pintail, lesser scaup, gadwall, and blue-winged teal then follow in the order named. That the canvasback nests recorded should have met with more than an average degree of success is not surprising, since 16 of the 29 were from the relatively crow-free pot-hole country about Prince Albert. What factors, however, conspired to permit shovelers to produce young in 64 percent of their nests while other species whose nests were essentially in the same environment and equally vulnerable fared much worse, is not clear.

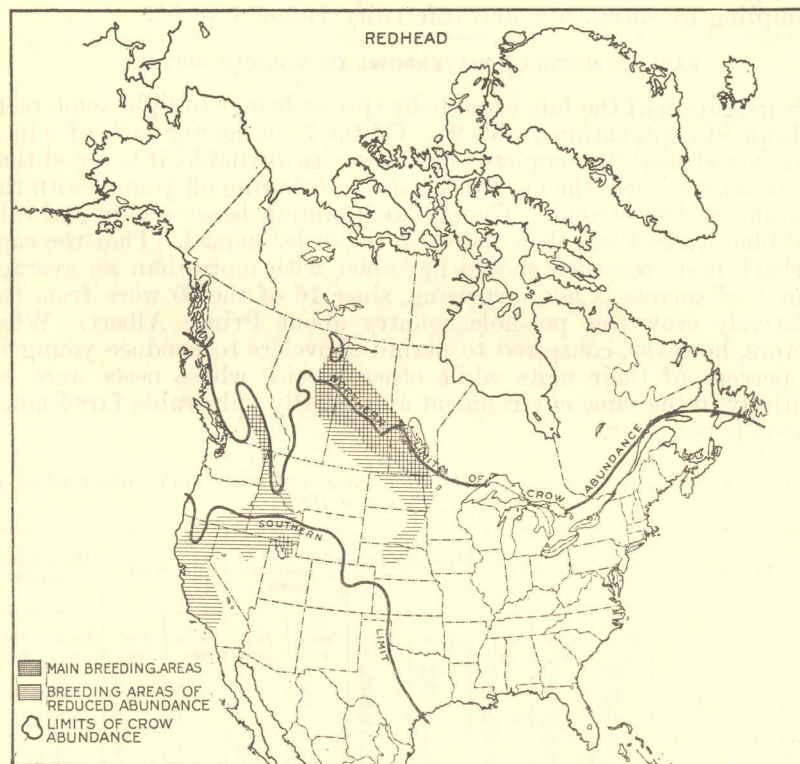
TABLE 2.—Analysis by species of the 512 waterfowl nests under observation in Canada, 1934 and 1935

Species	Total nests	Hatched		Destroyed by crows		Destroyed by unknown cause		Deserted		Miscellaneous fates	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Mallard.....	188	105	56	54	29	15	8	10	5	4	2
Lesser scaup.....	94	45	48	26	28	13	14	8	8	2	2
Blue-winged teal.....	76	17	22	35	46	15	20	8	11	1	1
Pintail.....	52	25	48	15	29	4	8	4	8	4	8
Canvasback.....	29	19	66	5	17	1	3	4	14		
Shoveler.....	25	16	64	4	16	3	12	1	4	1	4
Gadwall.....	21	10	48	10	48						
Redhead.....	8	4	50	3	37			1	13		
Ruddy duck.....	7	4	57	2	29	1	14				
Baldpate.....	5	4	80	1	20						
White-winged scoter.....	2					1	50	1	50		
Goldeneye.....	1	1	100								
Green-winged teal.....	1							1	100		
Unknown.....	3			1	33			2	67		
Total.....	512	250	49	156	31	53	10	40	8	13	2

Of the 7 waterfowl species represented by 20 or more nests, table 2 reveals that gadwalls fared the worst from crows, although the blue-winged teal suffered almost as badly. The 76 nests of the blue-wings yielded a total of only 163 ducklings, whereas, if each had produced its quota of 10.78 young (an average computed from the completed sets encountered in this study), the total would have been 820. The other well-represented species, placed in the order of their vulnerability to crow attack, are the pintail, mallard, lesser scaup, canvasback, and shoveler.



Had it been feasible to remain on the breeding grounds until studies of the last nests under observation could be completed, an improvement in the hatching record of scaups doubtless would have been noted. Most of the 75 nests on which studies had not been terminated when the field work was brought to a close were those of scaups. With conditions for the successful hatching of the eggs increasing daily near the close of the work, the addition of the records of 75 late nests would have materially increased the ratio of successful hatching.



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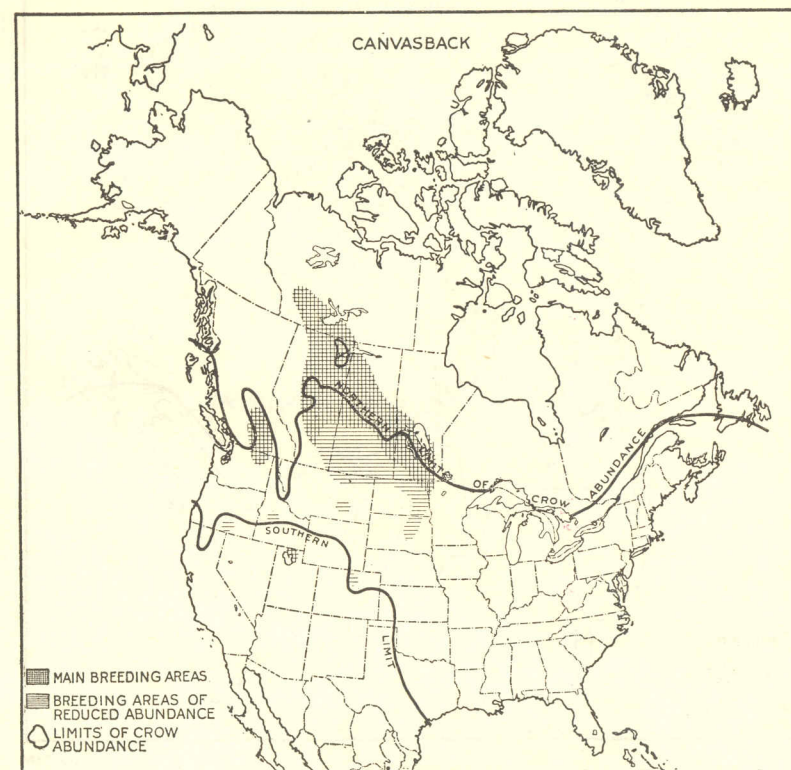
FIGURE 11.—Relation of areas of crow abundance to the breeding range of the redhead.

## SEASONAL VARIATIONS IN THE FATE OF NESTS

To ascertain the degree of success of early as against late nests, a division was made of the data pertaining to the 512 completed nest histories (table 3). This division, in which the termination dates of the various nest histories were used as the basis of segregation, was made at about the middle point of the field-study period in each of the two seasons. In the Saskatchewan studies of 1934 this division fell between June 18 and 19; in Alberta in 1935 it came between June 23 and 24; and in the studies made in the vicinity of Prince Albert in 1935 the division was placed between June 16 and 17.

TABLE 3.—Comparison of early and late nestings, showing outcome data for each half of the nesting season

Outcome	First half of season		Second half of season		Outcome	First half of season		Second half of season	
	Num-ber	Per-cent	Num-ber	Per-cent		Num-ber	Per-cent	Num-ber	Per-cent
Hatched.....	66	36	184	56	Female killed.....	5	3	4	1
Destroyed by crows.....	85	47	71	22	Miscellaneous fates.....	1	(1)	3	1
Destroyed by un-known cause.....	17	9	36	11					
Deserted.....	10	5	30	9	Total.....	184	100	328	100

<sup>1</sup> Trace.

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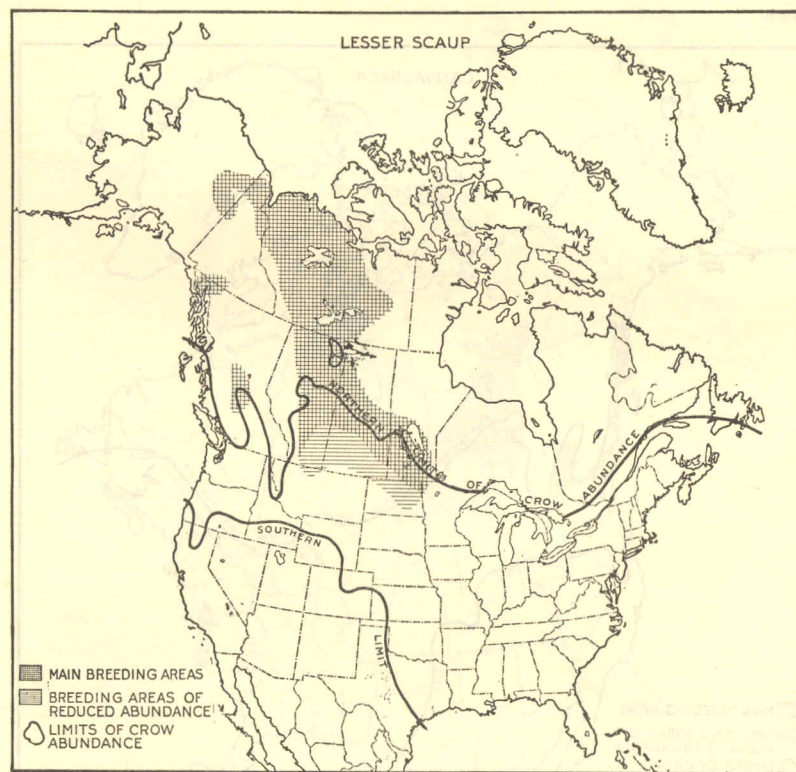
FIGURE 12.—Relation of areas of crow abundance to the breeding range of the canvasback.

It will be noted that there is a marked general improvement in the extent of successful hatching during the second half of the season and a corresponding decrease in the frequency of crow depredations. What is shown concretely in the table was even more apparent through field observations, which in many ways brought forth evidence of the lessened pressure exerted by crows as the season advanced. Toward the close of the studies, young crows of the year's hatch were out of the nest and had joined their parents in family groups that spent much of their time in the newly cut hayfields, on



summer fallow, or along roads. The duck-nesting environment no longer held the attraction to them that it had earlier in the year.

It has already been pointed out (p. 17) that incompleting sets of eggs did not fare worse than completed sets. It is also shown (p. 24) that poorly concealed nests, so frequently seen early in the season, did not meet with greater disaster than those well concealed. Yet the history of the whole group of nests clearly shows a marked increase in the number of successful hatchings as the season advances. This may be further emphasized by the explanation that, of the



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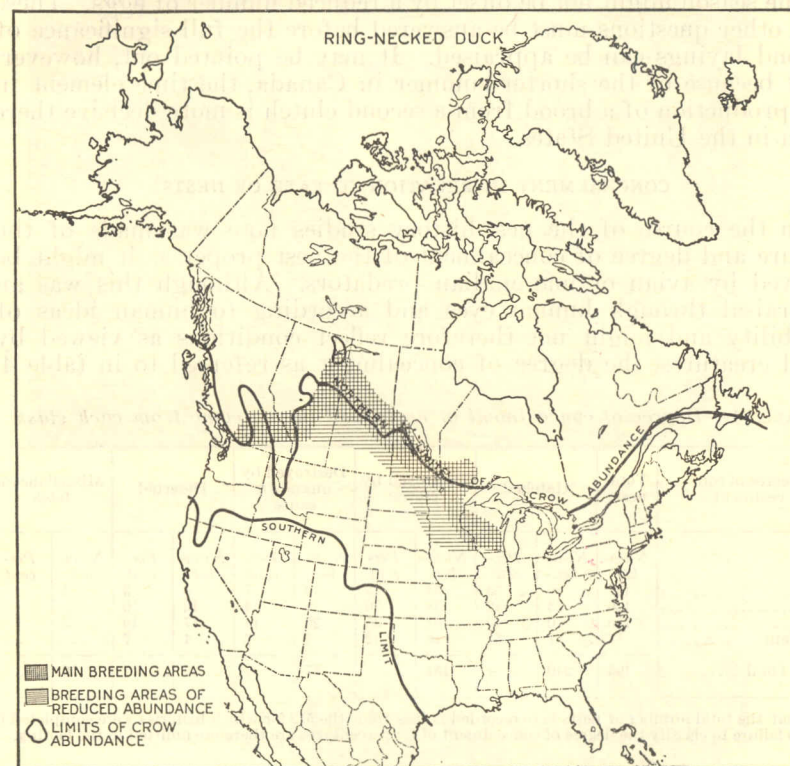
FIGURE 13.—Relation of areas of crow abundance to the breeding range of the lesser scaup duck.

last 42 nests terminated in the Cooking Lake district in 1935, 33—nearly 80 percent—produced young birds.

The reason for this seemingly anomalous situation may be found in the seasonal change in the habits of crows. Although from their very nature, duck eggs cannot furnish an appreciable proportion of the volume of food of nestling or adult crows, such food items have their maximum attraction for crows during their own reproductive period. At such times easily obtainable animal food is eagerly sought, particularly for the female under the strain of egg laying or under the confinement of incubation. Unless future studies alter matters, it would seem that, at least near the border line of agricul-

ture in the Prairie Provinces, crow damage to duck eggs is governed fully as much, if not more, by the nutritional demands or changing feeding habits of the crow itself as by an early-season vulnerability of duck nests.

The higher degree of success attained in late-season nestings calls for some comment on the possibility of second broods faring better than the first. This study provides nothing of a statistical nature on this subject, since it was impossible to define the status of many of the midseason nests, although a few extremely late nests of species



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FIGURE 14.—Relation of areas of crow abundance to the breeding range of the ring-necked duck.

that normally are early nesters might have been construed as second layings. This difficulty was accentuated in 1935, since the nesting season was 10 days to 2 weeks late, and many of the pintails and mallards did not settle down to nesting until in June.

Considering the time element alone as presented at the border line of agriculture in the Prairie Provinces, it would be possible for early nesting pintails, mallards, and some of the canvasbacks to have their nests destroyed and yet have ample time to remate and hatch a second laying at a time of year when the chance of success is better. It is not known what proportion of the midseason nesters, including the redhead, gadwall, ruddy duck, wigeon, shoveler, and blue-winged



teal, could raise a second brood in time to put them on the wing by the beginning of the fall migration. With the white-winged scoters and the scaups the chance of successfully raising a late brood is not favorable.

There is still much to be learned concerning the reaction of the various species to the loss of their eggs. It is not known what proportion of the birds will find their old or acquire new mates; build new nests; lay new sets of eggs; or patiently incubate them. If the second sets are smaller in size than the first, as some infer<sup>5</sup>, the question arises whether the advantage of better nesting conditions late in the season might not be offset by a reduced number of eggs. These and other questions must be answered before the full significance of second layings can be appraised. It may be pointed out, however, that because of the shorter summer in Canada, the time element in the production of a brood from a second clutch is more decisive there than in the United States.

#### CONCEALMENT IN RELATION TO FATE OF NESTS

In the course of the nest-history studies note was made of the nature and degree of concealment of the nest proper as it might be viewed by avian or mammalian predators. Although this was an appraisal through human eyes and according to human ideas of visibility and might not therefore reflect conditions as viewed by wild creatures, the degree of concealment as referred to in table 4,

TABLE 4.—Degree of concealment of nests, and the outcome from each class

Degree of concealment	Total nests	Hatched		Destroyed by crows		Destroyed by unknown cause		Deserted		Miscellaneous fates	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Poor.....	137	86	63	34	25	10	7	4	3	3	2
Fair.....	126	53	42	38	30	18	14	12	10	5	4
Good.....	175	70	40	61	35	25	14	17	10	2	1
Excellent.....	57	31	54	18	32	4	7	4	7		
Total.....	<sup>1</sup> 495	240		151		57		37		10	

<sup>1</sup> That the total number of nests here recorded is less than the 512 for which histories were completed is due to failure to classify the degree of concealment of 17; percentages are therefore omitted in the footing.

by the designations "poor", "fair", "good", and "excellent", conveys at least a relative idea of their visibility. Nests poor in concealment had little or no cover immediately above them, and at times the sitting bird could be seen from a distance. Those excellently concealed were wholly obscured from above and from the side, and the cover had to be parted or held aside before the nest proper could be seen (pl. 2, B). Nests considered fair or good in concealment were intergrades between the extremes described.

That adequate cover is essential to the welfare of most ground-nesting birds is generally recognized. This is particularly true in the case of waterfowl. It is with more than ordinary interest, therefore, that the fate of the Canadian duck nests was studied in rela-

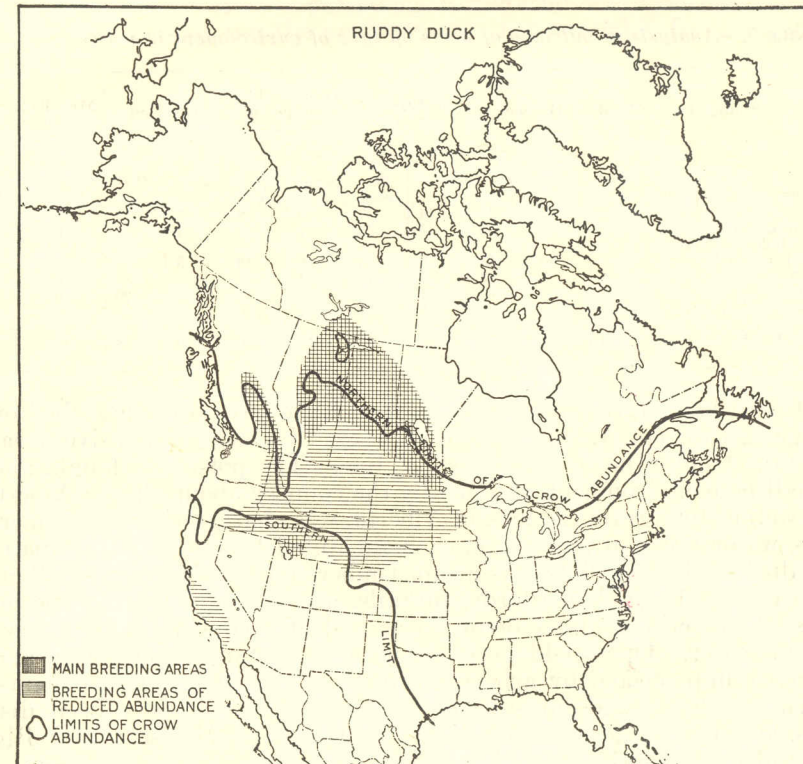
<sup>5</sup> BENNETT, L. J. A COMPARISON OF TWO IOWA DUCK NESTING SEASONS. Amer. Game Conf. Trans. 21: 277-282. 1935.



PLATE 3. SUCCESS AND FAILURE IN HATCHING. A, Nest of mallard on island in Ministink Lake, Alberta, Canada, that was reasonably well concealed from above by an arch of dead stems of round bulrush. The squarely cut shells and membranes of the eggs indicate a successful hatch. B, Typical crow work at nest of a canvasback, Sisib Lake, Alberta. The eggs had been destroyed when the nest was discovered by the investigators.



tion to that all-important factor, cover or concealment. The results presented in table 4 are quite at variance with what one would expect and they lead to the inference that perhaps human ideas of adequate concealment may not be correct or that the crows and other creatures that prey on ducks and their eggs are able, through astuteness, keenness of sight, or stealth, to overcome the protective advantage of what man sees fit to call adequate concealment (pl. 3, A). Then, too, there is the great likelihood that those individual ducks



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FIGURE 15.—Relation of areas of crow abundance to the breeding range of the ruddy duck.

whose nests are in exposed situations guard them more zealously and refuse to leave when danger impends.

Of the nests that terminated in hatchings, the highest degree of success was had by that group adjudged to have had poor concealment. Although the nests considered to possess optimum protection by reason of their excellent concealment showed a higher hatch than those with good or fair concealment, yet the successful hatching in the "excellent" group was materially below that of the poorly concealed nests. Equally startling deductions may be made when these data are scrutinized from the viewpoint of crow depredations (pl. 3, B). Analysis of the data pertaining to nests destroyed by unknown causes, or terminated by desertion and miscellaneous agencies, reveals somewhat the same state of affairs, those apparently



poorly concealed usually faring as well or even better than those that seemed excellently concealed.

#### LOCAL ENVIRONMENT AND FATE OF NESTS

As a basis for appraising the relation of local environmental conditions to the fate of nests, the habitats have been grouped (table 5) into six categories, referred to as (1) the dikes of Waterhen Lake, (2) open marsh, (3) pot holes, sloughs, and small lakes, (4) the bush, (4) open fields, and (6) island environments.

TABLE 5.—Analysis of outcome of nests by type of environment in which situated

Environment	Total	Hatched		Destroyed by crows		Destroyed by unknown cause		Deserted		Miscellaneous fates	
		Num-ber	Per-cent	Num-ber	Per-cent	Num-ber	Per-cent	Num-ber	Per-cent	Num-ber	Per-cent
Dikes at Waterhen Lake	221	102	46	74	33	20	9	17	8	8	4
Open marsh	37	11	30	15	40	7	19	4	11	0	0
Pot holes, sloughs, and small lakes	76	40	53	19	25	8	10	8	10	1	2
Bush	6	2	33	1	17	1	17	2	33	0	0
Open fields	5	3	60	1	20	0	0	1	20	0	0
Island environment	167	92	55	46	28	17	10	8	5	4	2
Total	512	250	49	156	31	53	10	40	8	13	2

Conditions on the dikes at Waterhen Lake have been described on pages 2 to 3 (pl. 1, A). The open marsh included expansive areas distant from either timber or shore line. The pot-hole, slough, and small-lake environment, typified by the country about Prince Albert, as well as by certain sections in Alberta, was characterized by numerous water areas of small size, each inhabited by one or a few pairs of ducks. By the "bush" is meant timbered areas, large or small, at the edges of which mallards, pintails, and the tree-nesting species nested, sometimes under dense cover and at a considerable distance from water. Open-field nests often were distant from water and usually unprotected by arboreal growth. The island environments, forming the second largest habitat group, have already been discussed (p. 4), and were restricted to Hastings, Ministik, and Big Island Lakes southeast of Edmonton (pl. 1, B).

The data in table 5 show that better-than-average success in hatching was obtained in the island, pot-hole, and open-field environments, although in the case last named the conclusion is based on five nests. The dike environment of Waterhen Lake, open-marsh areas, and the bush gave results less favorable than the average, although here again nests in the last category were few in number.

Leaving out of consideration the few nests in the bush and open-field environments, the most severe crow pressure was exerted on waterfowl on the dikes of Waterhen Lake and on open-marsh areas; whereas the pot-hole and island environments were most favorable for the ducks. A segregation of the data covering the nests in the pot-hole district about Prince Albert, where crows were less abundant, reveals an even more favorable situation. Only 3 of the 45 duck nests recorded in that section were despoiled by crows, and 33 of them hatched successfully.

#### FOOD OF CROWS AS REVEALED BY STOMACH EXAMINATION

To supply corroborative evidence of the fate of duck nests as revealed by field observation and to determine what proportion of the food of crows is obtained from the eggs and young of wild ducks in the area studied, 68 stomachs (25 of adults and 43 of nestlings) were collected in the Waterhen Lake district during the summer of 1934. These have since been examined in the laboratory and in presenting the results the food of adults and of nestlings will be discussed separately. Additional stomach material was also collected in Alberta in 1935 but the analyses were not available for this study.

#### ADULT CROWS

The various items making up the food of adult crows at Waterhen Lake, but not pertinent to crow-waterfowl relationships, can be passed over with the statement that the aggregate of all insect food items approximates that of adult crows in the United States taken during the same months (May, June, and July)<sup>6</sup> and that the vegetable portion is characterized by an abundance of wheat instead of Indian corn.

Remains of birds' eggs were found in 17 of the 25 stomachs of adult crows. In 4 of the 17 the shell fragments were definitely identified as eggs of ducks, in 12 others they were listed as "probably duck eggs"; and in the remaining instance the egg involved was apparently that of a meadowlark. In a single stomach the downy feathers of a young bird, probably a duckling, were found along with eggshell. In bulk, this material formed 4 percent of the aggregate stomach contents of the 25 adult crows. Compared with this degree of egg destruction on duck-nesting grounds in Canada, the writer<sup>6</sup> has found that 500 adult crows collected in the United States under varied conditions during the same season of the year had obtained a little more than 1 percent of their food from wild birds or their eggs.

The differences in the degree of bird and egg destruction in the two environments is brought out even more strongly when the case is stated on the basis of frequency with which these items appear in the stomachs. In the Canadian material, eggs (and in one instance, a young bird) occurred in 68 percent of the stomachs, while in 500 stomachs of adult crows collected in the United States during the same season, similar items appeared in only 33, or 6.6 percent.

#### NESTLINGS

In their general food habits the 43 Canadian nestling crows varied somewhat from those that have been collected in the United States. Only 32 percent of their food consisted of insects, as against 48 percent for the latter group. As was the case with the adults, small grains, including wheat, barley, and oats, took the place of Indian corn, the staff of life of crows in this country.

Remains of birds and their eggs were found in stomachs of 25 of the 43 nestlings from Canada. Of the 25, 21 contained shells of

<sup>6</sup> KALMBACH, E. R. THE CROW AND ITS RELATION TO MAN. U. S. Dept. Agr. Bull. 621, 93 pp., illus. 1918.



birds' eggs, of which 7 were definitely, and 5 tentatively, identified as those of ducks. The other egg remains were of small passerine birds. The downy feathers of ducklings were identified in three instances; grebe feathers in four; and the remains of young coots in two. In a few instances both eggs and feathers of birds were found in the same stomach. It was also revealed that all the individuals of a brood of young crows might be fed portions of the same item. Under such conditions the evidence of a single act of vandalism may be recorded in several stomachs.

In bulk, the remains of birds and eggs in the stomachs of the 43 nestling crows from Canada comprised 10 percent of the food. Nestling crows collected in the United States under a variety of conditions had subsisted on similar food to the extent of only 1.57 percent of their diet. Whereas birds and their eggs appeared in 58 percent of the stomachs of nestling crows collected in Canada, similar food was present in only 9 percent of 778 nestlings collected in the United States.

Summarizing the foregoing, it may be said that adult crows in Canada took four times the quantity of other birds and their eggs that those in the United States did; and that the nestling Canada crows took six times the quantity eaten by the young in this country. Stated on the basis of the frequency with which such controversial items are eaten, it may be said that the adult Canada crow is 10 times as culpable as the crow in the United States; while the nestling Canada crow is 6 times as bad in this respect as are nestlings raised south of the border.

This pronounced bird-and-egg destruction by crows in Canada is due, not so much to their northern situation as to the local environment where they were collected. Conditions at Waterhen Lake were favorable to the nest-destroying activities of crows. On the other hand, although the crows collected in the United States may have reflected average conditions in this country, the crow-waterfowl factor was largely absent from the environments in which stomachs were collected.

#### FATE OF DUCKLINGS

Study in the field yielded little information regarding the extent of mortality among ducklings from the time they are hatched until they are old enough to fly. Stomach examination, however, disclosed the remains of a duckling in 1 out of 25 adult crows and in 3 of 43 nestling crows. Whether all these ducklings were killed by crows or some were found as carrion could not be determined.

Although reports reached the investigators of the killing of ducklings by both crows and California gulls (*Larus californicus*), no instances came under their observation. Four dead scaup ducklings were found in one nest just after the eggs had hatched. Three of these had been decapitated, and the evidence pointed to the work of a weasel or a mink.

It is obvious that there will be certain losses during the period when the ducklings are small. These are accentuated and may even become serious when drought or absence of adequate cover compels the female to herd her brood long distances across open areas en route to bodies of water and shelter. When water levels are normal

and there is adequate marsh cover, such losses are materially reduced, and the crow, in particular, has little chance to prey upon the young.

A general impression of the extent of loss that may be suffered by young broods under conditions fairly favorable to their welfare may be had from data obtained in the course of these studies. Notation was made of the number of eggs found in all completed sets, and later counts were made of the young in single broods. A comparison of these data, with respect to lesser scaups, mallards, gadwalls, pintails, and canvasbacks, all obtained in the Cooking Lake district in 1935, shows with each species a reduction in the number of young as compared with the number of eggs. This information, grouped by species, is presented in table 6. The apparent losses are not outstanding with respect to any one species and may be looked upon as evidence of a natural and general drain, due to a number of causes. These no doubt include the crow, but such obscure factors as parasites, disease, accidents, and climatic conditions also play a part.

TABLE 6.—Comparison of the number of eggs in completed sets with the number of young in broods

Species	Eggs		Ducklings		Species	Eggs		Ducklings	
	Sets	Average number of eggs per set	Broods	Average number of ducklings per brood		Sets	Average number of eggs per set	Broods	Average number of ducklings per brood
	Number		Number			Number		Number	
Lesser scaup.....	50	9.54	16	8.00	Pintail.....	7	7.14	3	6.00
Mallard.....	45	7.84	32	7.10	Canvasback.....	7	11.70	10	8.70
Gadwall.....	12	10.50	4	8.50					

#### VALUE OF REMEDIAL MEASURES

This investigation has clearly indicated a heavy pressure exerted on nesting waterfowl by the crow in Canadian areas where it is conspicuously abundant. That being so, certain queries arise. Shall remedial measures be employed? If so, what kind? And, lastly, what result can be expected? The answer to the last of these questions will in large measure determine the nature and extent of any remedial action warranted.

Justly alarmed over a high degree of egg destruction such as is revealed by these studies, many urge unrestricted and unrelenting warfare upon the crow to remove what they feel is a potent hindrance to the recuperation of the waterfowl. They are convinced that such efforts would soon result in an appreciable increase in the number of North American game birds. In arriving at such conclusions two assumptions often are made: The first is that egg destruction by crows is everywhere as great as that disclosed in the Canadian localities studied; the second, that crows on this continent are to be found in destructive numbers wherever ducks breed.

As a matter of fact the waterfowl areas selected for study were those in which the crow was expected to be at its worst. The results



obtained, therefore, are not to be construed as average for the whole Dominion; nor are they to be interpreted as representative of crow-waterfowl relationships throughout this country. Future studies alone will show whether the 31-percent destruction of duck nests observed holds generally for all the duck-breeding grounds on this continent that lie within the crow's range of abundance.

As pointed out elsewhere (p. 12), the range of the crow in destructive abundance embraces only a part, possibly a sixth, of that great waterfowl area north of the United States which today is the reservoir from which come most of the ducks and geese. Since one cannot determine, even within broad limits, the fractional part of the actual wild-fowl population that is exposed to pronounced crow pressure, the matter can be disposed of only with the statement that the destruction of waterfowl eggs by crows, if prorated for the entire wild-fowl population of North America, will average materially less than the 31 percent recorded in the area studied. It is the writer's opinion that loss from this source will in the aggregate be less than 10 percent of the eggs laid. In areas heavily infested with crows, however, particularly on the waterfowl breeding grounds of the southern parts of the Prairie Provinces and in the North Central States, an egg loss approaching that disclosed in these studies may result.

To prevent such losses the difficult task of eliminating the crow would be necessary, and any effort falling short of complete elimination would be expected to fail proportionately in accomplishing its object. It is possible also that if the crow should be eliminated, other factors, now more or less inconsequential, might react to an increased yield of waterfowl and become correspondingly more potent suppressive agencies. Only actual control on a substantial scale, on experimental areas, accompanied by careful observations on its ultimate effect on the waterfowl population, will give the final answer to the value of crow control.

#### ON BREEDING GROUNDS OF WATERFOWL

On or about the breeding grounds of waterfowl, crow control takes on much the aspect of guerrilla warfare. Although crows may be abundant as breeders, there are no dense concentrations that can be attacked economically at that season. The cost per bird killed, therefore, is bound to be high whatever the method employed. Yet it is on the breeding grounds that crow control would give the most direct benefits to the harassed waterfowl. Individual crows, favorably located, are likely to become confirmed egg stealers and obtain much of their food at the expense of nesting ducks; others, not greatly distant, may conduct themselves less objectionably. The persistent marauder must be sought individually and its career ended.

This brings us to the crux of the whole problem of crow control on waterfowl breeding grounds: Control must be undertaken by those who have an intimate knowledge of the areas involved, a familiarity with the habits of local bird life, and a full appreciation of the hazards to waterfowl created by human intrusion at the nesting time. Without such appreciation, efforts at crow control may react disastrously on the very waterfowl it is sought to aid. On

refuges and other areas under supervision, the resident warden or caretaker usually is in the best position to deal with egg-stealing crows. Under no conditions should large groups of loosely supervised crow hunters, operating as they frequently do on a competitive basis, be allowed to intrude on waterfowl nesting areas during the spring months.

Three methods of crow control on breeding grounds are at the disposal of the trained refuge caretaker and game manager—shooting, trapping, and poisoning. When the area is not too large and the crows not too numerous, shooting with a small-bore rifle is effective and does not unduly disturb nesting ducks. Such operations may well be delayed until all the crows have taken up their nesting sites and there is little likelihood of the arrival of additional migrants. In the Northern States such operations can be started in April; in Canada in May. In both regions they can be continued until the objectionable resident crows in and about the waterfowl areas have been removed. During the nesting season a crow call, imitative of a young bird, and a mounted owl exposed near a concealed shooting stand, will be found effective in luring adults within gunshot. Effort should be made to get both the male and female of each nest, and, if there are young, these also should be dispatched.

A .22-caliber rifle, with or without telescope sights, using standard long-rifle ammunition will be found satisfactory. The higher powered ammunition, discharging .22-caliber bullets at greater velocities, is not recommended in thickly settled areas because of the menace to human beings and livestock. Away from the immediate vicinity of nesting grounds the shotgun may be used with greater freedom.

Trapping with steel traps is a useful practice at the disposal of a refuge caretaker to eliminate individual egg-stealing crows. Such traps (no. 0 or no. 1) may be used in connection with a "set", baited either with hen's egg or the body of a ground squirrel or other rodent. The jaws may be padded to prevent injury to beneficial creatures that may be caught accidentally. Traps may with advantage be set near the scene of previous egg destruction, as crows often return to such places.

The use of poison in crow control on breeding grounds has both advantages and disadvantages. Moreover, it may be legal or illegal, depending on local laws and regulations, which must be respected at all times. Before any further consideration of the subject, however, it cannot be too emphatically stated that poisoning is a procedure to be shunned by persons unfamiliar with its use and its dangers. In the hands of the experienced, however, poison can be used with a reasonably high degree of selectivity, safety, and effectiveness.

A hen's egg is the ordinary medium for conveying poison for egg-stealing crows, and strychnine is the usual poison employed. In island environments or on extensive areas where valuable dogs or fur bearers would not get them, such eggs may be put in dummy nests placed on or near the ground; elsewhere the nests should be placed well above the ground. In thickly settled sections, the use of poisoned eggs should be scrupulously avoided, since crows often will carry and drop them at distances from the baited area. These eggs usually are prepared by being partially blown, after which,



with a hypodermic needle and syringe, a small quantity of poison in solution is injected, the contents well shaken, and the aperture in the shell sealed with a piece of adhesive tape.

#### AT WINTER ROOSTS

Contrasted with the time-consuming and expensive, but highly selective, procedure of disposing of particular egg-stealing crows on breeding grounds is the alternative of crow control at winter roosts, where, at a much lower cost per bird, large numbers have been removed by trapping, shooting, poisoning, or dynamiting. Winter gatherings of crows are made up of individuals that breed over an enormous range and in a great variety of environments, and only part of these birds are concerned in crow-waterfowl relationships during spring and summer months—what that proportion is no one at present knows. The efficacy, therefore, of winter crow-control operations as an aid to the betterment of waterfowl conditions on breeding grounds far to the north cannot be stated definitely, though on the average it must be small. Unless winter-control operations should result in a decided reduction in the aggregate number of crows throughout the country, it is doubtful to the writer whether a noticeable improvement in the continental supply of waterfowl would result.

Although fall and winter crow control can be defended on some areas as a local crop-protection measure (and there are ample reasons for further research into such methods of control) no one should become overly sanguine regarding the possible benefits resulting to waterfowl. Regardless of the method or the season chosen for control, it must be remembered that crows are highly mobile and resourceful and that reinvasions may be expected into areas from which they have been extirpated. Permanent advantages from control operations will rest on continued effort, and any ground that may have been gained may be easily lost through a lapse in the operations.<sup>7</sup>

#### SUMMARY

To gather data on crow-waterfowl relationships, studies were made during the nesting seasons of 1934 and 1935 in the vicinities of Prince Albert and Waterhen Lake, Saskatchewan, and southeast of Edmonton, Alberta, the field observation being supplemented by stomach examination. Complete histories were obtained of 512 nests of ducks and the fate of each was determined as far as the facts could be ascertained. Despite the care used, the intrusion of the observer may have affected the results somewhat in favor of the crow and other predators, at least with respect to the extent of nest desertion. About Waterhen Lake, Saskatchewan, and Cooking Lake, Alberta, where most of the nest histories were obtained, the abundant population of breeding crows was reflected in the extent of nest depredations. On the other hand, in the pot-hole district about

Prince Albert, where breeding crows were less abundant, only moderate losses were suffered by nesting ducks. For this reason the findings of this study cannot be construed as representative of conditions everywhere in Canada and much less so on breeding grounds in the United States. The essential findings may be summarized as follows:

1. Of the 512 duck nests studied, 250 (49 percent) produced young. In some instances the number of the eggs was reduced by one cause or another before hatching. Crows were definitely chargeable with the destruction of 156 nests (31 percent), though some of these may have been deserted by the female before the eggs were eaten. Unknown causes accounted for the loss of 53 nests (10 percent). Nests deserted by the female numbered 40 (8 percent), and the remaining 13 (2 percent) met miscellaneous fates, at 9 of which the incubating bird was killed by predators.

2. Of seven species of ducks for each of which at least 20 completed nest histories are available, the canvasback and shoveler were most successful in producing young, while the gadwall and blue-winged teal fared the worst. Many of the canvasback nests were near Prince Albert, a section where the crow population was less dense.

3. Despite the fact that poorly concealed nests or incomplete sets of eggs were found not to have suffered more from crow attack than those well hidden or with full complements of eggs, there was a decided improvement in the extent of hatching as the season advanced. This would indicate that egg destruction by the crow in Canada is governed as much by the nutritional demands and habits of the crow itself as by any early-season vulnerability of the nests.

4. Though some of the early-nesting pintails and mallards have time to hatch second layings, when the chance of success is greater, it is not known what proportion of the midseason nesters could do likewise. Late-nesting scaups are even less likely to have the young from second nestings hatched and on the wing before the advent of cold weather and the opening of the hunting season.

5. Local environmental conditions were reflected in the fate of nests; those in "open-field", "island", and "pot-hole" environments having fared better than those found on the dikes at Waterhen Lake or in the "open-marsh" areas elsewhere.

6. Stomach examination revealed that adult crows in the Canadian duck-nesting environments averaged four times as many birds and eggs eaten as do adult crows living under average conditions in this country. At the same time nestling crows north of the border ate six times the quantity of such food that nestlings to the south did. This indication of pronounced bird and egg destruction is due largely to the fact that all the crows collected in Canada were obtained in close proximity to duck-nesting grounds, whereas those collected in this country were taken in a variety of environments, among which duck-nesting grounds were infrequent, if not entirely lacking.

7. No pronounced mortality of ducklings was attributable to the work of crows or other predators. If there is ample marsh cover and water levels are stable the female ducks are not forced to lead their young long distances to water and losses of the ducklings from this cause are not excessive.

<sup>7</sup> Methods of combatting crows destructive to crops are presented in the following: KALMBACH, E. R. THE CROW IN RELATION TO AGRICULTURE. U. S. Dept. Agr., Farmers' Bull. 1102. 20 pp., illus. 1920. This bulletin may be obtained from the Office of Information, Department of Agriculture, Washington, D. C., without charge, as long as the supply lasts.



8. Since the areas studied were selected with the idea of witnessing the crow at its worst probably a higher degree of egg destruction was revealed than would be the average throughout the range of the crow on this continent. Furthermore, since the crow is found in abundance on only part of the waterfowl breeding areas, the aggregate egg loss, if prorated for the entire waterfowl population of North America, would be materially less, possibly not more than a tenth of the eggs laid. Locally, however, there may be egg losses approaching those indicated by these studies among waterfowl that breed in the southern part of the Prairie Provinces and in the North Central States.

#### CONCLUSIONS AND RECOMMENDATIONS

Field studies of the fate of duck nests in Canada reveal that there are areas near the northern border of agriculture in Saskatchewan and Alberta in which the presence of an inordinately dense crow population is a menace to duck-nesting marshes, but that where crows are less abundant, as in the pot-hole country about Prince Albert, Saskatchewan, losses are correspondingly less severe.

Waterfowl have been the victims of the combined effects of over-shooting, drought, disease, predators, and destruction of habitat, but the crow in Canada has suffered little from any of these and has even profited to the extent that agriculture has displaced the bush with open fields, grain crops, and plowed land. In recent years crows that nest in the Prairie Provinces have found also on their winter range in Kansas and Oklahoma an increased and copious food supply in the milo, kafir, and other sorghum crops. These circumstances favor the abundance of the crow at the expense of waterfowl.

Although the findings of this study are sufficiently disturbing to merit attention in programs of waterfowl restoration where crows are numerous, unwarranted conclusions and ill-advised action should be carefully guarded against. On the areas studied the crow was probably at its worst. Its normal role as a predator on the eggs of waterfowl throughout Canada and the northern United States is yet to be determined, but the indications point to its being less severe than these studies have revealed. In any event, it is to be remembered that the range of the crow in destructive numbers now covers only a part (possibly a sixth) of the whole productive waterfowl nesting area in Canada and Alaska. Beyond the limits of these overlapping ranges there is no serious crow-waterfowl problem.

Waterfowl, in common with all other bird life, can ordinarily withstand what might be termed "natural losses" during the reproductive period. The fecundity of most species is sufficient to compensate for any ordinary drain. Where, however, conditions similar to those encountered in these studies arise on important areas dedicated primarily to the welfare of nesting waterfowl, rational crow control should become an integral part of any game-management program.

Crow-control operations on duck-breeding grounds should by all means be entrusted only to those who fully recognize the hazards associated with human intrusion on waterfowl nesting grounds. The work should not be carried out haphazard or by mass action devoid of careful supervision. There should, in fact, be solicitude for the

privacy of every nesting duck. At winter crow roosts, where control is possible at a lower cost per bird, the benefits with respect to waterfowl are, in turn, less direct, since only a part of the birds present at these roosts (number at present unknown) actually enter the problem of crow-waterfowl relationships on the breeding grounds.

For the present, and probably for years to come, such control may wisely be restricted to those Federal, State, or privately managed areas to which crows have been attracted in unduly large numbers by the presence of nesting waterfowl and on which the consequently delicate problem of control may be kept in experienced hands.



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